

Modelling the potential effect of shared bicycles on public transport travel times in Greater Helsinki: An open data approach[☆]



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A B S T R A C T

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In many European cities, support for public transport and cycling in daily mobility is considered an efficient means to reduce air pollution, traffic jams, and carbon emissions. Shared bicycle systems have turned out effective in increasing cycling in many urban areas, particularly when combined with public transportation. In this study, we make an effort to model a hypothetical shared bike system and quantify its spatial effect on public transport travel times. The study area is one of the fastest growing urban agglomerations in Europe, the Greater Helsinki area in Finland. We model the travel times between the population and 16 important destinations in the city centre of Helsinki by public transportation and by public transportation extended with shared bikes. We use open route and timetable databases and tools developed in-house to perform extensive data mining through application programming interfaces (APIs). We show 1) that open transport information interfaces can provide a new effective means to evaluate multimodal accessibility patterns in urban areas and 2) that the launch of a bicycle sharing system could reduce public transportation travel times in the study area on average by more than 10%, meaning some 6 min per each individual trip. We conclude that bicycle sharing systems complementing the traditional public transport system could potentially increase the competitiveness and attractiveness of sustainable modes of urban transport and thus help cities to promote sustainable daily mobility. Finally, we emphasize that the availability of open data sources on urban transport information – such as the public transport data in our case – is vital for analysis of multimodal urban mobility patterns.

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Introduction

With growing urban population and increasing daily traffic, the development of more sustainable urban transportation systems is crucial in many cities around the world (Pucher, Garrard, & Greaves, 2010; Tight et al., 2011). Public transportation and cycling are increasingly promoted to mitigate traffic-related problems such as traffic jams, pollution, expensive road infrastructure, accidents and congestion. In comparison to private cars, cycling is considered a quiet, fast, healthy, emissions free, equal and space-efficient means

of transport (Andersen, Schnohr, & Schroll, 2000; Chapman, 2007; Dekoster & Schollaert, 1999; Jensen, Rouquier, Ovtracht, & Robardet, 2010; Pucher, Komanoff, & Schimek, 1999; Tolley, 1996).

Consequently, many cities and public authorities have created strategies to increase cycling and are investing in bicycle lanes, shared bicycles or 'bike and ride' schemes (Lumsdon & Tolley, 2001; Martens, 2007; Midgley, 2009; Pucher et al., 2010). On the other hand, studies (Goetzke & Rave, 2011; Keijer & Rietveld, 2000; Müller, Tscharaktschiew, & Haase, 2008; Pucher & Buehler, 2006; Rietveld & Daniel, 2004) have shown that cycling may not be an appealing option if distances grow, particularly in areas with varying weather or hilly topography. Krizek and Stonebraker (2010) have identified factors affecting bicycle use in the travel chain. In summary, people are more likely to use cycling transit in suburbs than in the city centre and fast long distance transit seems to draw more cycling transit users. Short egress distances usually mean more cycling transit users, most likely on trips to work or school.

Martens (2007), Pucher et al. (2010) and Krizek and Stonebraker (2010) propose that efficiently integrating bicycling into public

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transport could increase the share of sustainable means of transport. This is interesting because, according to Martens (2004), bicycles and public transport have traditionally been seen as competitors and their synergy possibilities have largely been ignored. Perhaps consequently, integrating bicycle and public transport in the activity end is seldom seamless or flexible. In some countries, bicycles are nevertheless widely used to access public transport stations (Keijer & Rietveld, 2000), but the share is substantially smaller on the egress part of the trip due to the limited availability of bicycles (Keijer & Rietveld, 2000; Martens, 2004). Modern bicycle sharing schemes have the potential to overcome some major shortcomings of integrating bicycle and public transportation. Shared bicycles (also known as public bicycles or smart bikes) are bikes that are generally available for loan, usually for a small deposit. In its most popular form, bicycles are checked out and returned to unattended stations located throughout the city. This system enables citizens to use bicycles on a flexible “as needed” basis (Shaheen, Guzman, & Zhang, 2010). After the launch of the first extensive modern bicycle sharing system (BSS) in Lyon in 2005 (DeMaio, 2009), the number of cities implementing such schemes has grown rapidly (Midgley, 2011) despite challenges, foremost the imbalances in supply and demand of bicycles. One of the main goals of BSSs have been to enhance accessibility by public transport and to improve the competitiveness of sustainable means of transport by integrating bicycles into urban transportation systems (Lin & Yang, 2011; Midgley, 2009; Shaheen et al., 2010). The first results suggest that these goals might be attainable, as shared bike trips have replaced car trips (Bührmann, 2007; Nadal, 2008), and the share of trips by bicycle has increased (Bührmann, 2007).

Due to the relatively short history of modern BSS, research on such systems and their impacts is still quite scarce, although growing rapidly. Most BSS studies have focused mainly on identifying spatiotemporal trends from the station hire data (Borgnat et al., 2011; Froehlich, Neumann, & Oliver, 2009; Kaltenbrunner, Meza, Grivolla, Codina, & Banchs, 2010) or on optimizing BSS station locations and the number of bikes (García-Palomares, Gutiérrez, & Latorre, 2012; Lin & Yang, 2011; Lin, Yang, & Chang, 2011; Sayarshad, Tavassoli, & Zhao, 2012; Vogel, Greiser, & Mattfeld, 2011). Studies assessing BSSs as a part of the public transport system from spatial viewpoint are, however, scarcer (see, however, Anaya & Bea, 2009; Bührmann, 2007; Nadal, 2008).

Enhancing accessibility by sustainable means of transport is one of the key aims of BSSs. For long, reliable GIS analyses of multimodal trips have been too data hungry and computationally intensive to calculate over large extents. During the past years, the situation has changed remarkably as public administration, NGO's and private companies are opening network datasets and/or programming interfaces that allow batch routing along road and public transportation networks (Lei & Church 2010; Martin, Jordan, & Roderick, 2008). In Europe, this development is partially resulting from the PSI and INSPIRE directives, open data activism and, importantly, cities' competition on innovative entrepreneurship (Bakici, Almirall, & Wareham, 2013; Hielkema & Hongisto, 2013). The availability of standardized data formats (e.g. the General Transit Feed Specification) and increased computing capacity (e.g. cloud computing) are making intensive multimodal transport analyses feasible for a larger group of researchers and practitioners (Yang, Raskin, Goodchild, & Gahegan, 2010). Different fields of science are reacting on this development on a different phase: whilst the use of open data and related discussions is already commonplace, for example, among biological sciences (e.g. Molloy, 2011; Reichman, Jones, & Schildhauer, 2011), the potential of open data is yet to be fully discovered among urban studies.

In this paper, we use openly available data sources and routing interface to quantify the potential impact of a bicycle sharing

system on public transport travel times and to analyse the formation of the BSS's spatial pattern. Greater Helsinki (the capital region of Finland) provides an ideal test case for such an analysis: there are plans to implement a modern BSS in the region, public transport route and timetable databases as well as spatially referenced population statistics are openly available for everyone via a query interface (Journey Planner, 2012) and regional data service (<http://www.hri.fi/en/>). Our specific study questions are:

- 1) Would a bicycle sharing system influence public transportation travel times? If so, how much and in what kind of areas in the city structure? Where would be the busiest bike hubs be located?
- 2) Could such questions be answered with freely available data sources and routing interfaces, mainly planned for public transport users?

In practice, we compare travel times and travel routes between inhabited 250-m × 250-m grid squares ($n = 6906$) in Greater Helsinki and 16 important points of interest (POIs) in the Helsinki city centre using 1) public transportation (PT) alone, 2) bicycles alone, and 3) a combination of the two (PT + BSS).

Data and methods

Study area

Our study area Greater Helsinki is the largest urban agglomeration in Finland both economically and in number of inhabitants (ca. 1 million) (Fig. 1). Compared to many European cities of similar size, the urban fabric (particularly population) of Greater Helsinki is relatively scattered (European Environment Agency, 2006). After the 1950s, the capital region experienced a structural change in the form of suburbanization (Vaattovaara, 2011) but despite the growth of sub-centres, the Helsinki city centre remains by far the strongest centre in the region (Vasanen, 2012) with highest population and job densities.

In comparison to other European cities, residents are satisfied with the public transportation system (European Commission, 2010), which consists of a metro line covering the eastern suburbs, three commuter railway lines to the north, northwest and west of the city, a tram network of 12 lines in the extended city centre, a ferry line, and an extensive bus network (Fig. 1). Despite the good public transport connections, the city is experiencing increasing traffic by private cars, more traffic jams and parking problems.

The city aims to increase the share of cyclists from 9% to 15% by the year 2020, despite the challenges of Helsinki's northerly weather conditions (the city can experience on average 3 full months of snow cover during the winter months). In the past decade, the city has established a number of new bicycle lanes in the city centre and dedicated bicycle pockets in front of traffic lights. Special emphasis has been put to the winter maintenance of bicycle lanes. The mid-2000s saw a small scale bicycle sharing system operating in the Helsinki city centre. To become a part of citizens' daily mobility the system was, however, too small, using old technology (coin deposit) and the bicycles were poor (Helsinki City Transport, 2008). Now there are plans to launch a modern and considerably larger BSS.

Data

In our analyses, we used different data sources, as specified in Fig. 2. Firstly, data on population by buildings from the year 2010 (Helsinki Region Environmental Service Authority, 2011) was aggregated to 250-m grid squares. This served to identify the

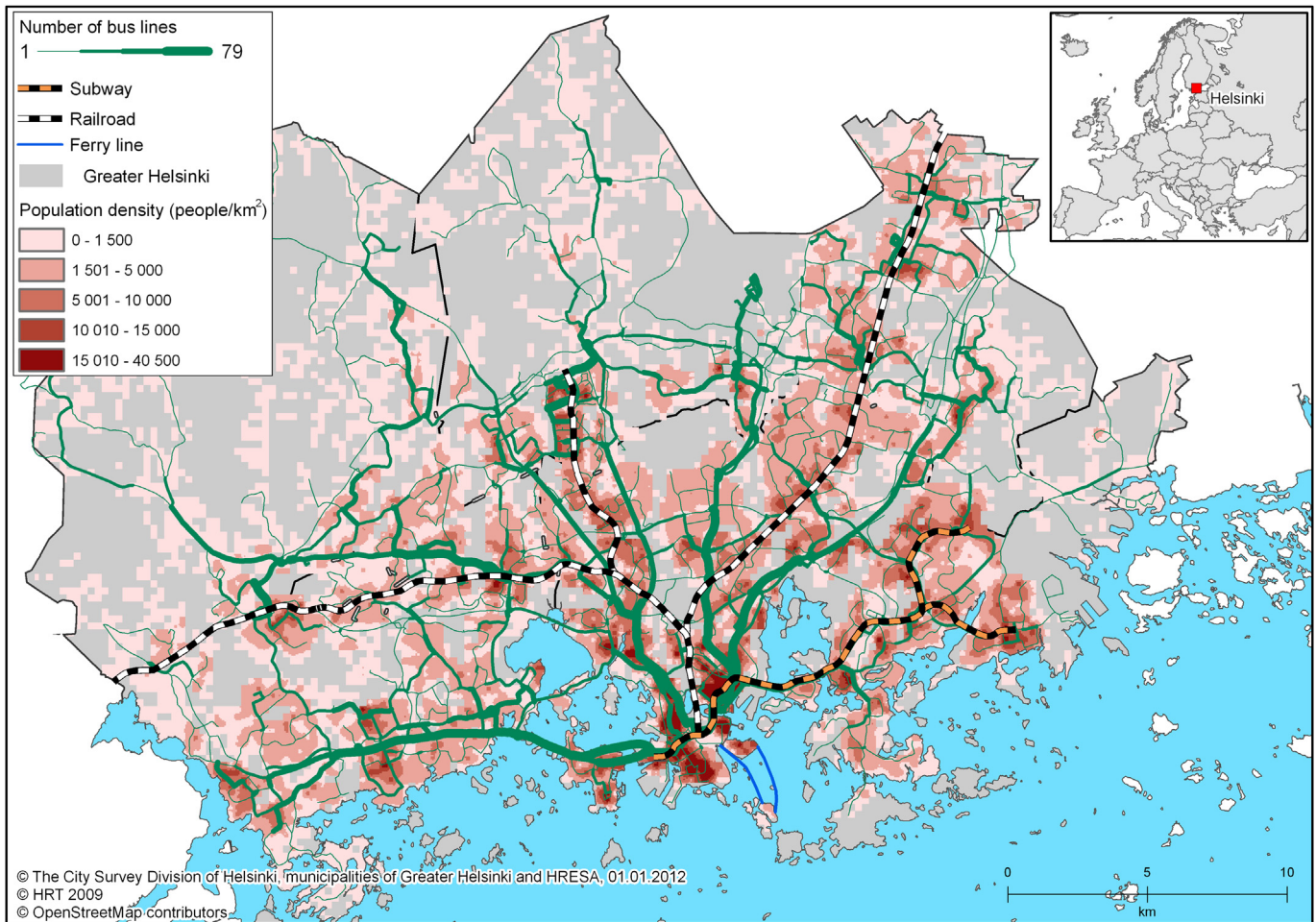


Fig. 1. The public transport system and population density in Greater Helsinki.

inhabited grid squares and to weight travel time and spatial pattern calculations.

Secondly, we defined 16 major points of interest (POIs) inside the planned usage area of the BSS (Helsinki City Transport, 2008) as destinations of daily mobility (Fig. 3). The POIs (major employment concentrations, shopping destinations, university campuses,

recreational areas, and tourist attractions) were selected for the analyses based on their 1) significance for different daily activities, and 2) their spatial separation to represent different types of locations within the city (central location vs. suburban location).

Thirdly, we measured the time needed to access and egress a shared bike at a shared bike station with a simple stopwatch

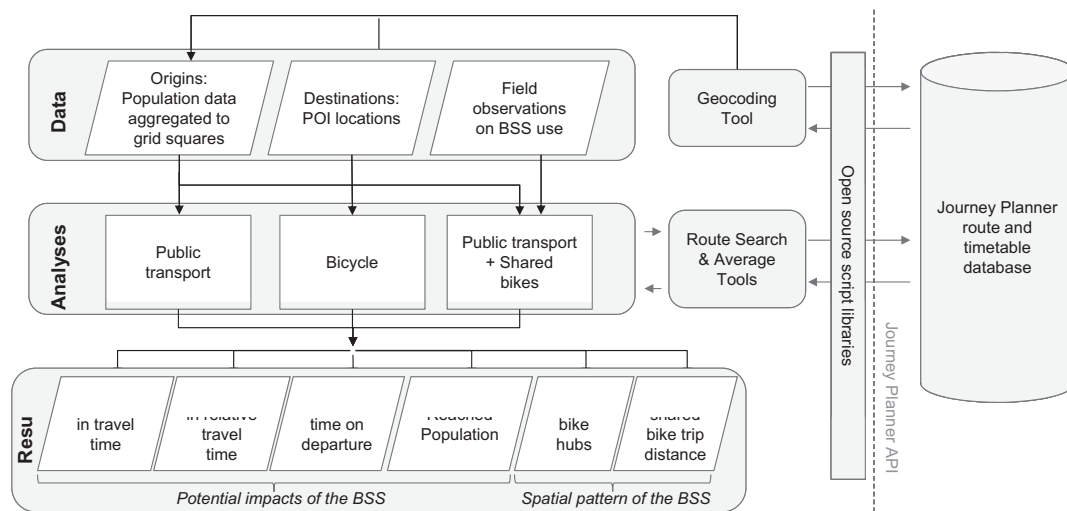


Fig. 2. Study design: data, analyses, and results.

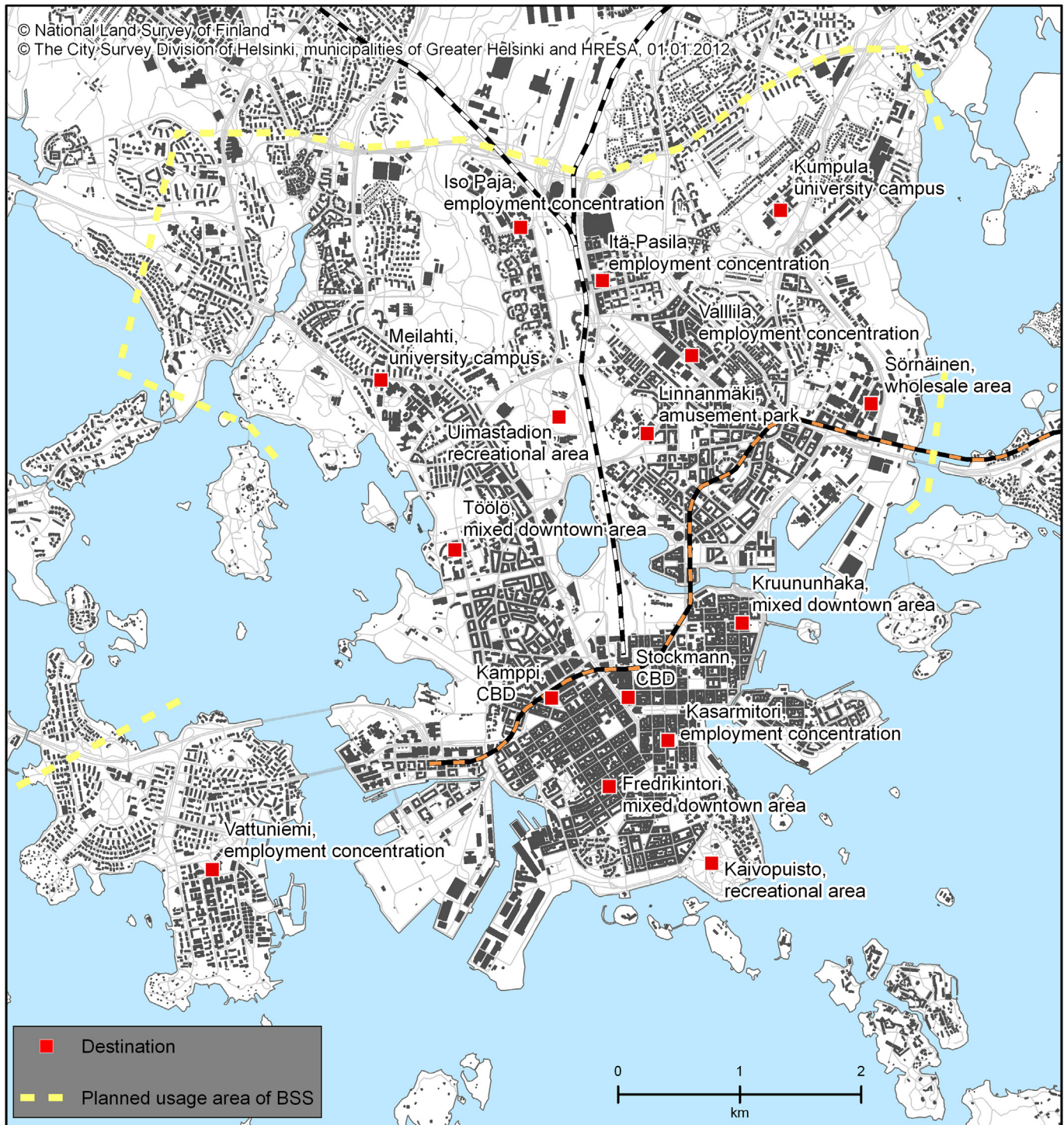


Fig. 3. The 16 points of interest (POIs) selected in the Helsinki city centre. We measured travel times from all inhabited 250-m grid squares ($n = 6906$) to these destinations using public transportation, bicycles, and a combination of the two (i.e. public transport combined with a shared bike system).

method. The observations were made in Lyon (France) and Valencia (Spain) in September and October 2011. Shared bike stations were observed in both cities during three days, on average two hours at a time, making 25 stopwatch measures in Lyon and 20 in Valencia. The values used in analysis were set based on these observations, using time that is needed for a regular user to access and egress the bike comfortably.

Lastly, we used public transport route and timetable databases (including also walking routes) produced by Helsinki Region

Transport. These databases were accessed through an open API ([Journey Planner HTTP Get Interface](http://journeyplanner.fi), 2012).

Route modelling tools

Journey Planner is a public internet service provided by Helsinki Region Transport, the regional authority responsible for the planning and provision of public transportation (PT) in the capital region of Finland as well as for providing information about it

Table 1
Route searchers, their inputs, and settings.

	Route search 1	Route search 2	Route search 3	Route search 4	Route search 5
Route analysis using...	Public transport	Bicycle	PT + BSS (part 1)	PT + BSS (part 2)	PT + BSS (part 3)
Origins	250-m grids	250-m grids	250-m grids	Shared bike hubs	250-m grids
Destinations	16 POIs	16 POIs	16 POIs	16 POIs	Shared bike hubs
Walking speed	70 m/min	300 m/min	300 m/min	300 m/min	70 m/min
Number of routes suggested	3	1	1	1	3
Means of transport used	All	Non-motorized modes	All	Non-motorized modes	All
Transfer safety margin	3 min	3 min	3 min	3 min	3 min
Cost of walking time compared to time spent in public transport	1.2	Not used	1.2	Not used	1.2

(Journey Planner, 2012). The service is designed to find the optimal route between a given origin and destination by public transport at a given time of day. It provides the user with a detailed description of the trip chain, including the walk from the origin to the first PT stop, all the necessary PT lines and transfer stops, and the walk from the last PT stop to the final destination. Users can specify route search settings such as walking speed, preferred means of transport, transfer time margin and penalty for additional transfers. Journey Planner timetables take into account the temporal variability resulting from congestion and headways.

Three different tools were programmed to query the databases of the Journey Planner API (Fig. 2). Firstly, we created a Geocoding Tool to convert address locations to lists of map coordinates that act as inputs to the routing. This tool served to convert the destination addresses to a list of map coordinates. Secondly, we created a Route Search Tool to extract as a text file the Journey Planner route suggestions for routes between origins and destinations at a given time of day. The Route Search Tool receives as inputs the coordinates of the origins and destinations as well as a number of settings that the user can customize. It then returns the travel time, travel distance and actual travel chain for all origin-destination pairs as a tabular text file. Lastly, the Average Tool was used to calculate averages from the route search outputs (Fig. 2). The Average Tool reads the different route suggestions for the same OD-pair (by default

Journey Planner offers three different route suggestions for one trip) as an input and calculates averages of them. All of the tools were written in Ruby and they took advantage of existing script libraries maintained by the Github open source community.

Analysis

We selected a regular weekday, Wednesday, 23 November 2011, as the date of the study. We examined the temporal variation during a single day by running the routing analyses at two different times of day: arrival times to destinations were set as morning (rush hour, 9 am) and mid-evening (8 pm). We did not study differences between weekdays and the weekend. We applied the Journey Planner default values for basic settings, such as transfer time margin (3 min), walking speed (70 m/min) and cycling speed (300 m/min).

Modelling travel times by public transportation (Route search 1)

In the analysis, we set the mid-points of inhabited 250-m × 250-m squares in Greater Helsinki ($n = 6906$) as origins and the 16 points of interest as destinations, and applied default Journey Planner settings (Table 1, Route search 1). We used the Average Tool to calculate route averages for each origin-destination (OD) pair from the three suggested routes.

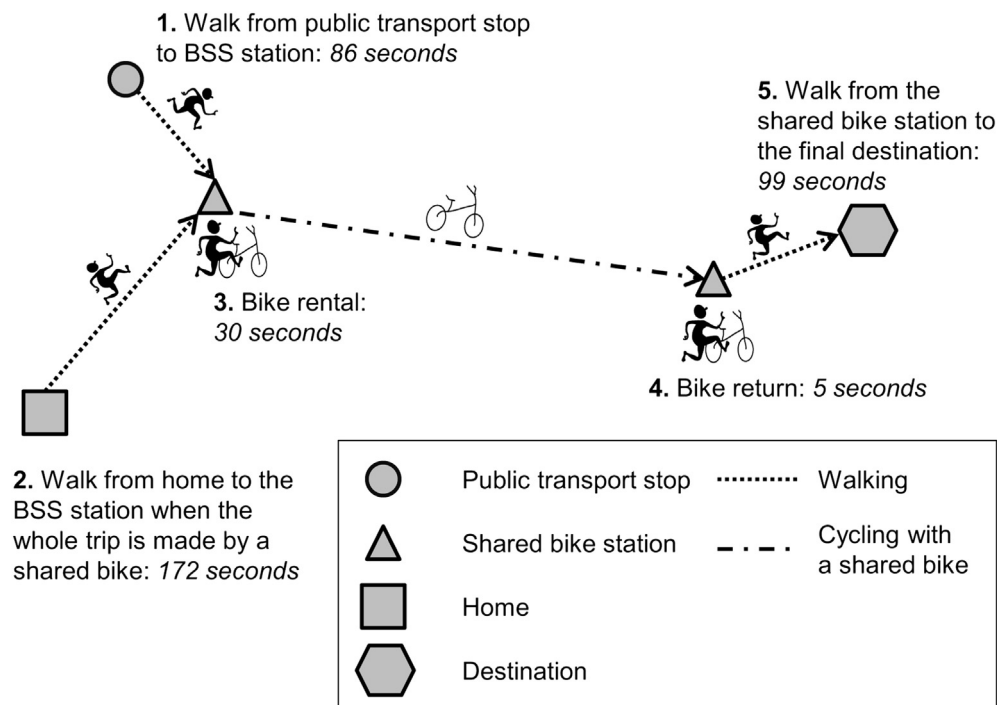


Fig. 4. Formation of time penalties in public transportation and bicycle sharing system analyses.

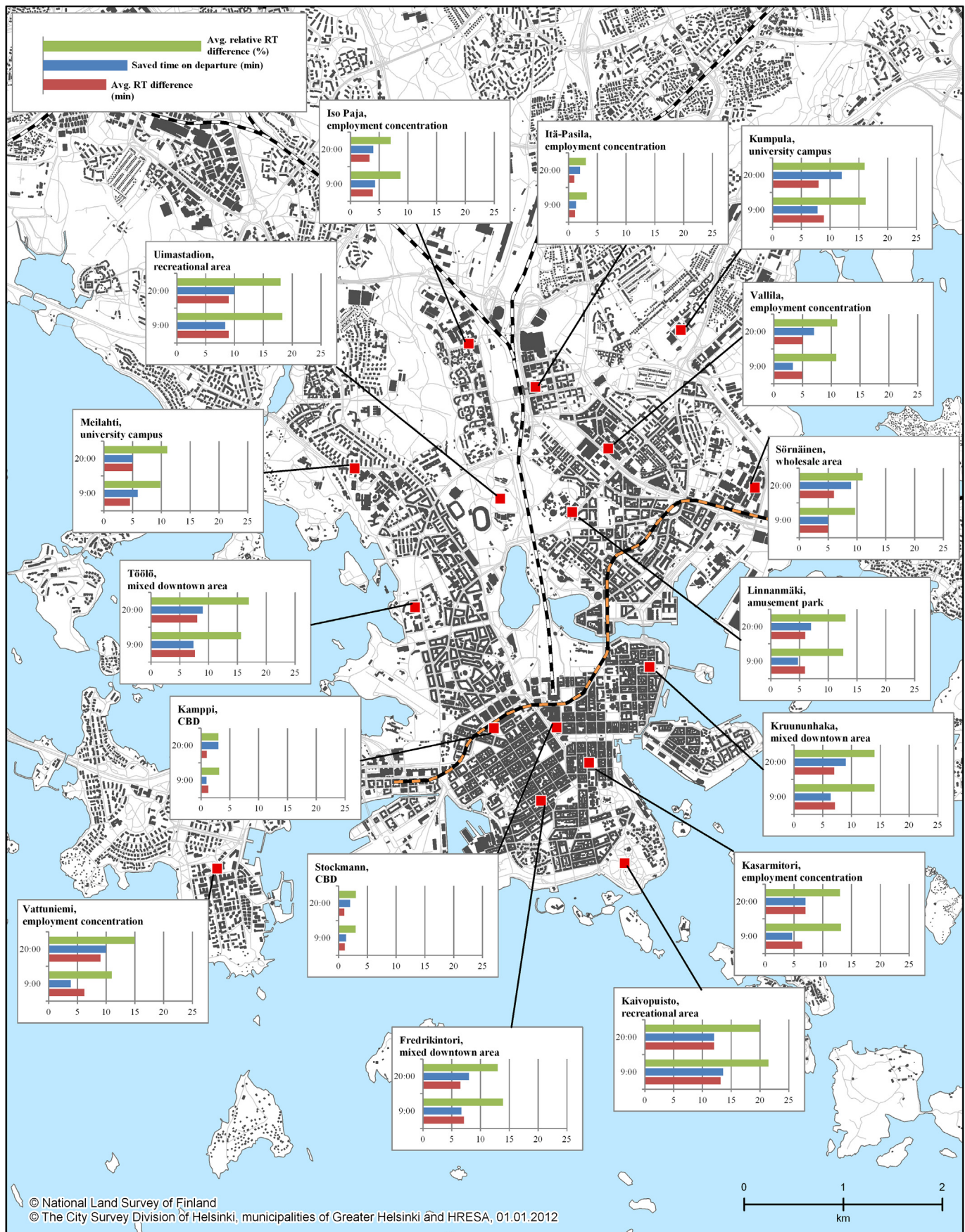


Fig. 5. The effect of a bicycle sharing system on average public transport travel times, calculated from all inhabited grid squares in Greater Helsinki to 16 designated points of interest.

Modelling travel times by regular bicycle (Route search 2)

Again, the mid-points of the inhabited squares served as the origin inputs, and the 16 points of interest were the destination inputs. This time, we set the bicycling speed (300 m/min) as the walking speed and disallowed the use of other means of transportation (Table 1, Route search 2). These settings force the routing to walking routes, so that for example parkways can now serve as routes, whereas motorways cannot. As there was no bicycle infrastructure information available for use in the Journey Planner database, we had to work with the pedestrian network which is a clear limitation of the model.

Modelling travel times by public transportation + shared bikes (Route searches 3–5)

To model travel times with a bicycle sharing system (BSS), we first had to determine the point towards the end of the trip at which cycling becomes a faster option than public transport. This is the point where a passenger should hop off the public transport vehicle and cycle the rest of the way to the destination. To do this, we had to run three subsequent routings (route searches 3–5 in Table 1) and combine the results. We assumed that BSS was available only in the city centre area (see delineation in Fig. 3).

First, we identified the last public transport stops along the suggested routes (e.g., the stops where passengers would switch to bikes, if available) by using the default routing, but with bicycle speeds (300 m/min) as the walking speed (Table 1, Route search 3). We then stored the last public transportation stop for each OD pair

for both times of day. Later in this article these stops are referred to as *shared bike hubs*.

For the next phase, we calculated travel times from the shared bike hubs to destination POIs. We set the cycling speed as the walking speed, and walking as the only option (Table 1, Route search 4). After this, we knew how long it would take to bike from shared bike hubs to destinations. Because shared bike stations are not always located immediately next to public transport stops or destinations, and because hiring and returning a bike takes time, we added “time penalties” to the travel times found in the previous route search. Fig. 4 illustrates the calculation of the time penalties. Walking from the last public transport stop to the shared bike station (Fig. 4: phase 1), renting the bike (Fig. 4: phase 3), returning the bike (Fig. 4: phase 4) and walking from the shared bike station to the final destination (Fig. 4: phase 5) all take time and thus incur a time penalty. If the whole trip was made by shared bike, then an additional time penalty of 86 s was added because we assumed the walking time was longer closer to the residential areas than in transport hubs. Walking distances were based on observations in Lyon and Valencia as well as previous BSS plans in the Helsinki city centre (Helsinki City Transport, 2008). By reducing the travel times from hubs to destinations (Route search 4) and setting the time penalties for the destination arrival times (9 am and 8 pm), we knew the time of day by which one should be at a specific shared bike hub in order to arrive at a specific destination in time.

Lastly, we used the default settings to make another route search (Table 1, Route search 5) from the mid-points of the

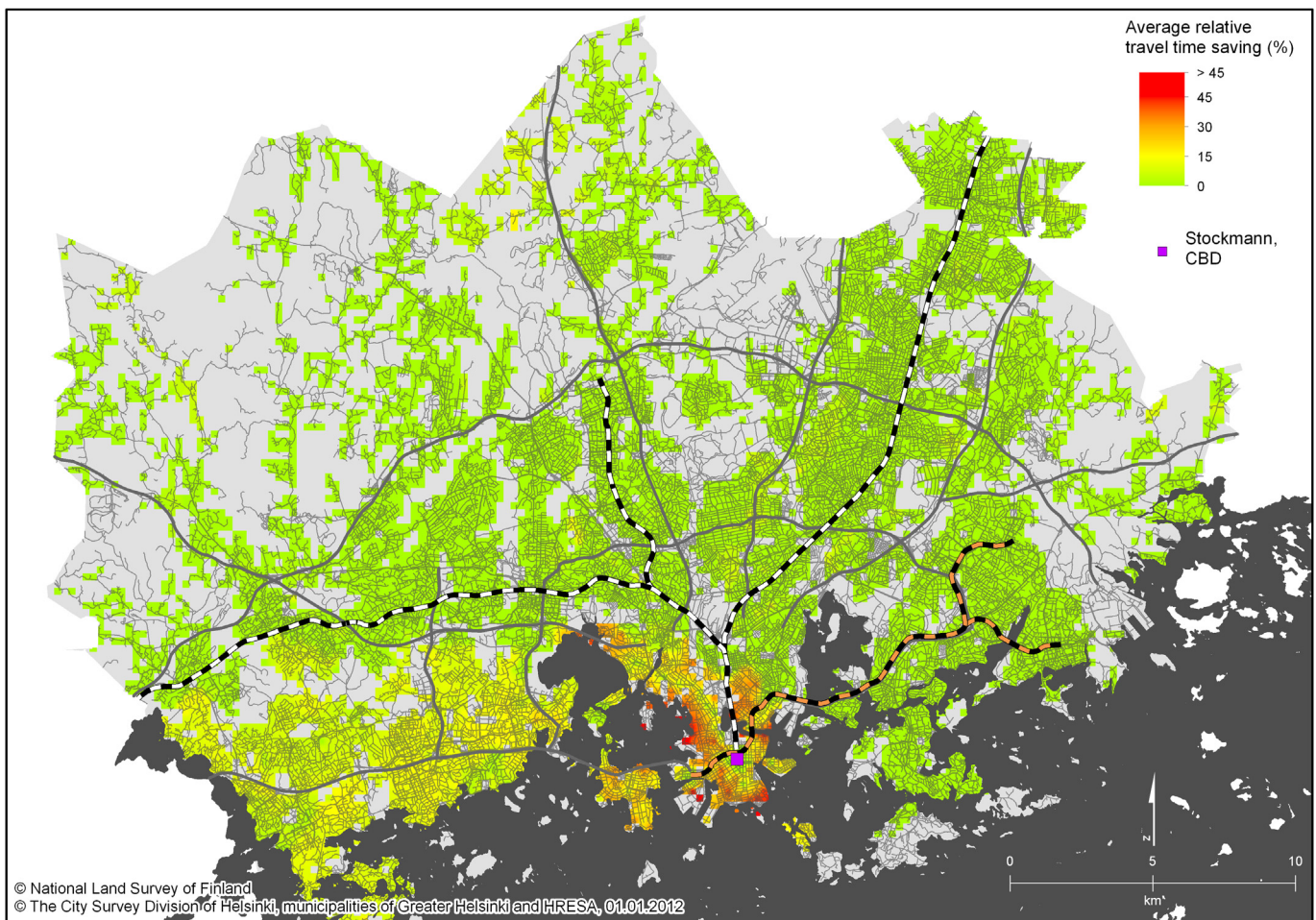


Fig. 6. Example of a central destination: Travel time savings to point of interest “Stockmann” in the city centre at 9 am.

inhabited squares (origins input) to the shared bike hubs (destinations input). Arrival times to the hubs were set based on the calculations from the previous phase. After the route searches, we used the Average Tool to calculate the average travel times for the three alternative suggestions given by Journey Planner. Total travel times were calculated by summing the average travel time from the mid-point of a grid square to the shared bike hub and the time from hub to the destination POIs (including the penalties).

Analyzing the impact of the bicycle sharing system

We derived four measures from the previously described routings to analyse the impacts of a bicycle sharing system on public transport travel times (see Fig. 2):

- 1) Decrease in travel time: Travel time with current public transport – travel time with public transport & shared bicycles
- 2) Decrease in relative travel time: (Travel time with current public transport – travel time with public transport & shared bicycles)/travel time with current public transport
- 3) Saved time on the departure, i.e. increase in “couch time”: Departure time with current public transportation – departure time with public transport & shared bicycles
- 4) Amount of population reached by the different modes of transport: calculated based on population data on different time distance zones.

Regional impacts of the BSS are illustrated in this paper through 2 of the 16 destinations: the Stockmann department store situated

in the heart of the city centre and the Vallila employment concentration located at the edge of the city centre area.

Exploring the spatial pattern of the bicycle sharing system

We derived two additional measures to describe the spatial pattern of the BSS, as it appears based on our routings (see Fig. 2):

- 1) The busiest shared bike hubs were identified by calculating the amount of people hiring a bike at each hub (assuming that each person in the study area would make one trip from his/her home to each POI at both times of day).
- 2) Average length of a shared bike trip was calculated based on trip distances of Route search 4 (Table 1).

Results

Regional impacts of the bicycle sharing system

The results show that a BSS would decrease public transportation travel times. On average, travel times between origins and destinations would be approximately six minutes shorter with BSS + PT than with PT alone (Fig. 5), meaning an average reduction of 10% in travel times throughout the entire region.

The impact of BSS is not uniform, however. Travel times to destinations close to the main public transport hubs remain almost the same with PT as with PT + BSS, but travel times to more remote places decrease significantly with a BSS. When looking at the amount of time one saves on the departure, one can, on average,

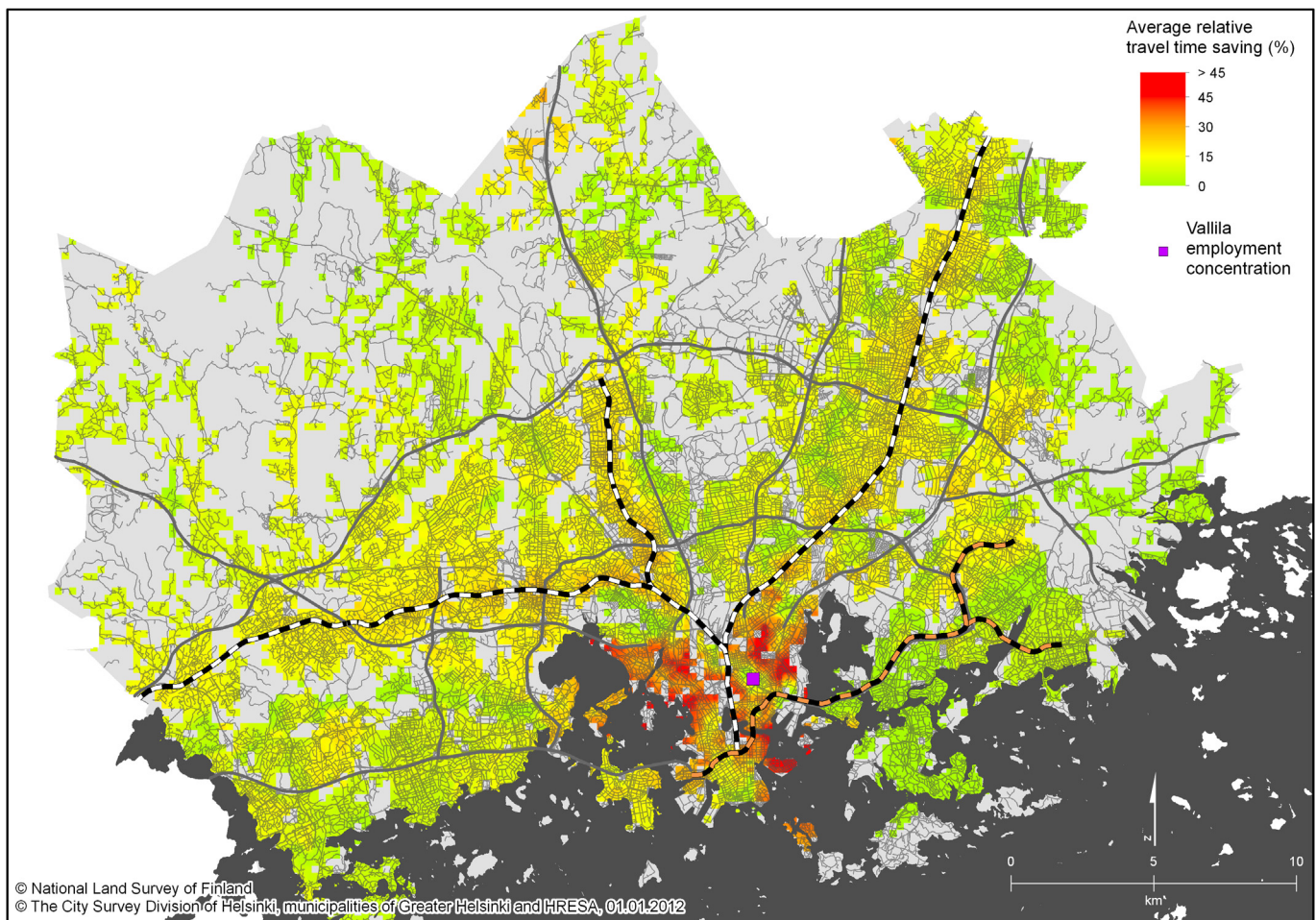


Fig. 7. Example of a less central destination: Travel time savings to point of interest “Vallila” employment concentration at 9 am.

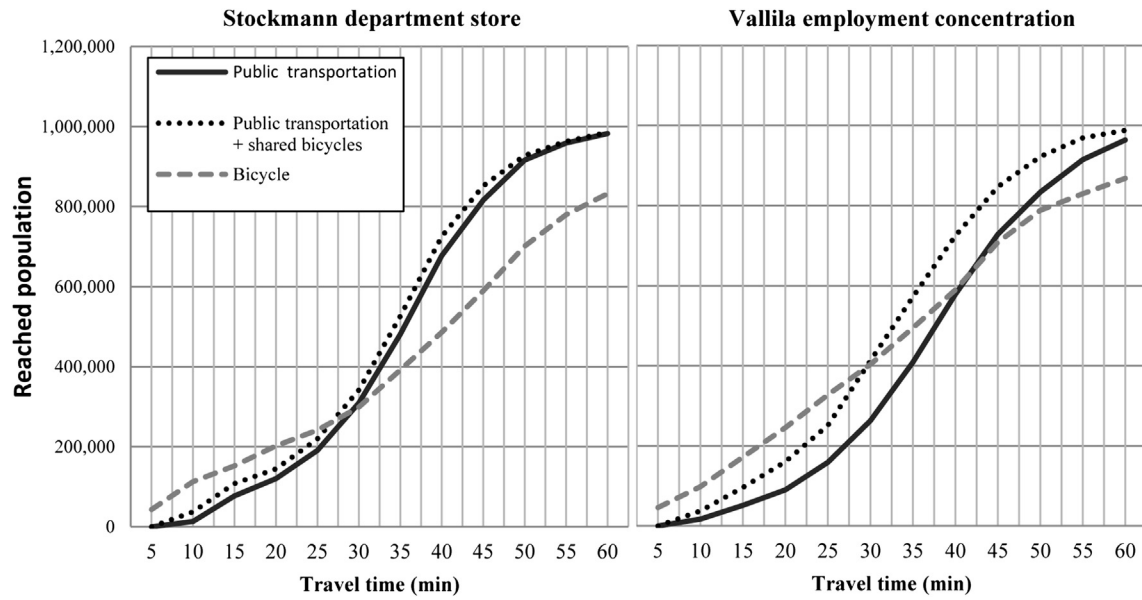


Fig. 8. Population reached within different travel times from a central POI (Stockmann department store) and an employment concentration POI (Vallila) using different means of transport.

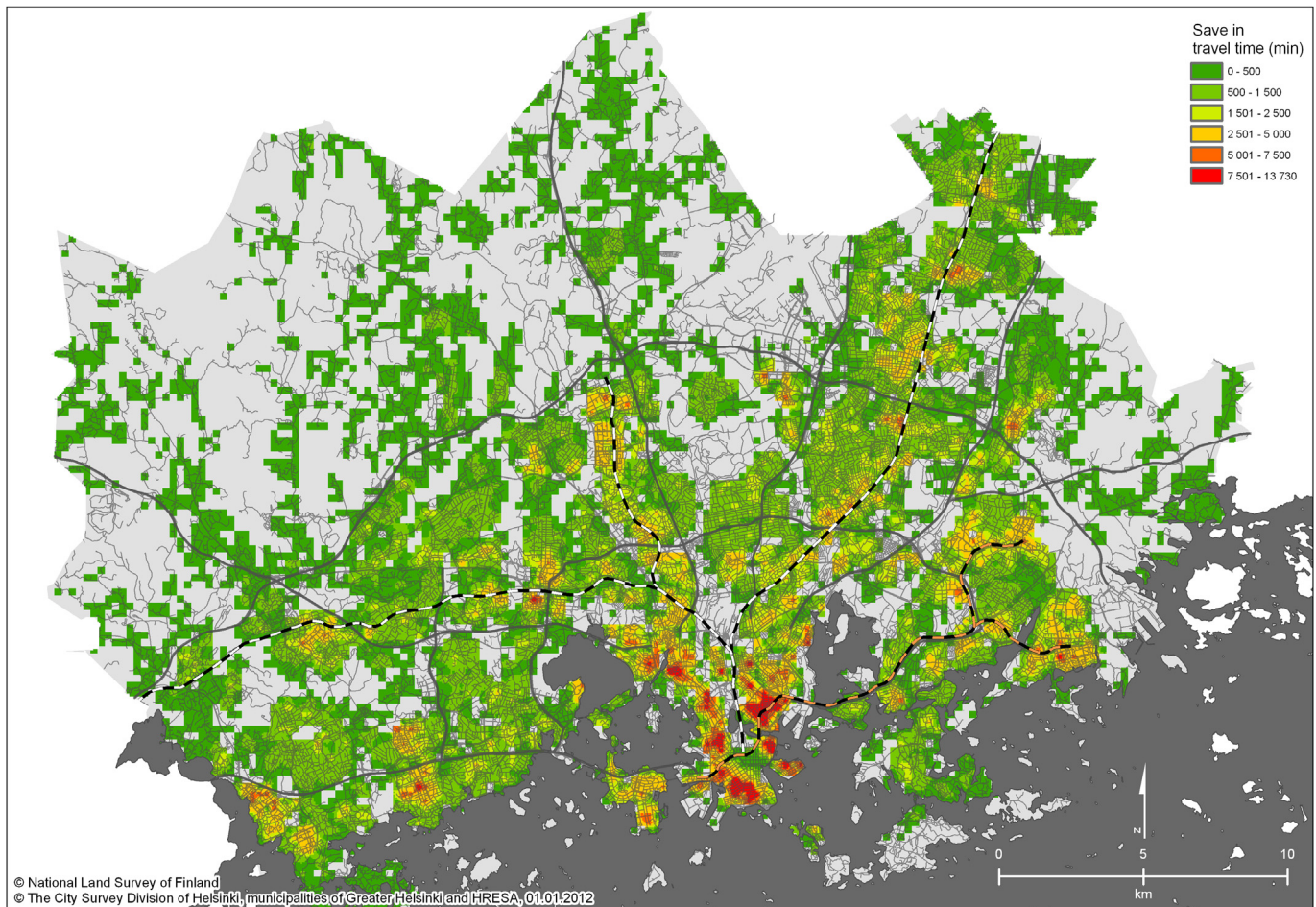


Fig. 9. Summed travel time saving to all 16 POIs, weighted by population of the 250 × 250 m grid cell.

leave home approximately six minutes later under a BSS. Again, the greatest departure time savings are observed on trips to more remote locations. In some destinations there are clear differences between morning and evening trips but generally the differences in time savings between the different times of day remain small (Fig. 5).

As an example, relative decreases in travel times to the very centre of the city (POI Stockmann) are negligible, as Stockmann is located close to the Helsinki central railway station as well as to several metro stations and bus terminals (see Fig. 5). The largest decreases in the case of Stockmann occur in areas close to the point of interest, where using a shared bike for the entire trip is the best option (Fig. 6). In comparison, for points of interest in the Vallila employment concentration, residential areas close to railway stations would benefit the most from a BSS. Over 15 per cents' decreases in travel times occur in many occasions (Fig. 7). Again, bicycles appear to be a faster option than public transport when the origin of the trip is fairly close to the destination.

Overall, however, travel time savings would spread relatively evenly across the entire city region. When calculating average travel time savings to all 16 of the destinations, the majority of the population in Greater Helsinki lives in a zone that would benefit from reductions of 5 to 7.5 min in travel time to the city centre. Some 5000 inhabitants would see travel time savings of greater than ten minutes.

Effect of bicycle sharing system on reached population

The competitiveness of PT + BSS is highlighted when travel times are observed through the amount of reached population (Fig. 8). Again, the difference between PT alone and PT + BSS is small when looking at the city centre area (e.g. Stockmann department store). The difference is much greater in the Vallila employment concentration, where the greatest difference in travel times is 35 min. In that time, PT + BSS are able to reach 160 000 more people than PT alone. Regular bicycles appear to be a competitive mode of transport because it is a faster option than current public transport for trips under 30 min (or approximately 9 km). Even with a BSS, regular bicycles remain competitive on trips under 25 min (Fig. 8). Travel time savings cumulatively to all 16 points of interest show a clear pattern (Fig. 9): BSS would serve well the densely populated areas close to the downtown Helsinki. Here, parts of the PT trips are replaced entirely by BSS trips. However, the impact is considerable even in the more remote locations of the Greater Helsinki.

Spatial pattern of the bicycle sharing system

The busiest shared bike hubs are found close to the railway and metro stations in the city centre area (Fig. 10). Around 45% of the bicycle hires occur at just two locations: the Pasila railway station and the Helsinki central railway station. The next largest hubs are

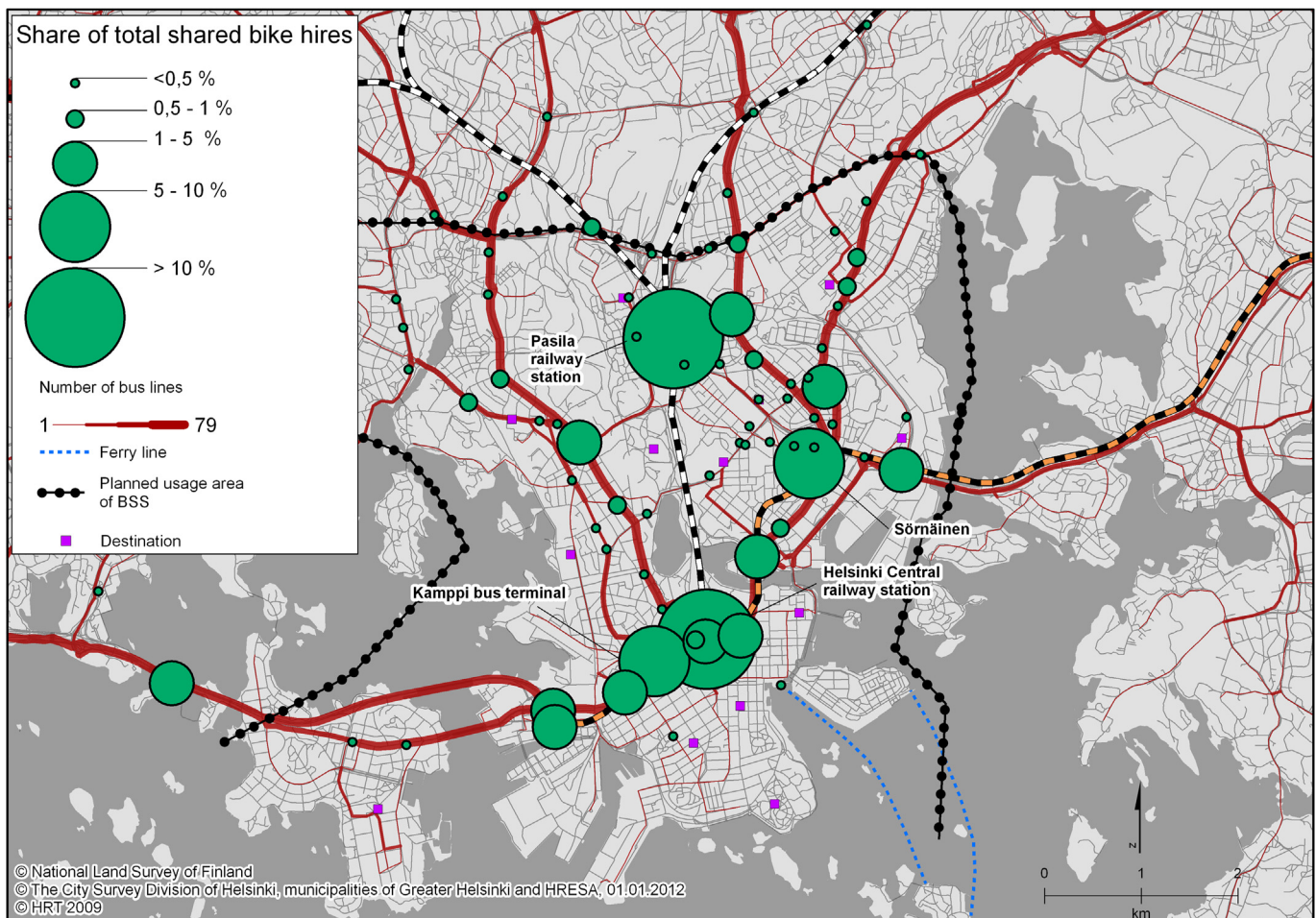


Fig. 10. The most optimal shared bike hubs based on the analysis.

the Kamppi bus terminal and the Sörnäinen metro stop, both of which are important public transport stations. All 8 of the railway and metro stations in the city centre area are amongst the 13 largest shared bike hubs.

The average length of a shared bike trip would be approximately 1.5 km, although this varies greatly by destination, mostly as a function of differences between the destination's location in relation to the public transport system, bike trips being shorter to destinations closer to the main public transport hubs.

Discussion

Options for more sustainable urban mobility: possible benefits of a bicycle sharing system

The competitiveness of sustainable means of transport is essential if we are to change urban mobility habits. Accessibility, particularly travel time, is one of the most influential factors affecting peoples' perceptions on competitiveness of the different modes: as Frank, Bradley, Kavage, Chapman, and Lawton (2008) suggest, a considerable growth in public transport usage could be achieved through shortening transit travel times. As this study shows, more thoroughly integrating different sustainable modes of transport has the potential to improve accessibility by them, and can thus increase their competitiveness relative to the private car: according to our results, extending public transportation with shared bicycles yields clear time savings for the population of the study area. Eventually this can affect travel mode shares, as the Vélib system in France has shown (Nadal, 2008).

In our model, the average distance travelled by a shared bike ended up being slightly shorter than the length of an average trip in some already operational European systems (Anaya & Bea, 2009; Jensen et al., 2010). Thus, one can consider the modelled trip chains realistic or at least capable of being done. Based on our results, a large-scale bicycle sharing system would have at least reasonable effect on public transport travel times, or more precisely, on access and egress times. The benefits are particularly clear for destinations located just outside the city centre (e.g., the Vallila employment concentration in our case) or for such short distances that bicycle replaces public transportation altogether. Although the time savings on an individual trip may not seem impressive (6 min or 10% on average), they become considerable when weighted by the potential number of service users: as there are close to 500 000 public transport trips made to or originated from the city centre every day (Helsinki Region Transport, 2010), the sum of saved time per day would equal 500 h if shared bikes would be used even on 5000 trips per day. Much of the time saving occurs in access and egress to PT, as suggested by Wu and Murray (2005). However, time savings occur also on the actual PT trip: with improved access and egress, the users may choose more speedy PT connections to their trip.

Clearly, for detailed estimates of cumulative time savings and their economic revenue, we should take into account the demographics of the region, local weather conditions, and the inhabitants' true travel behaviour (Krzek & Stonebraker, 2010; Ryley, 2006). Such cost-benefit calculations are facilitated by data openings and increasingly used in economic appraisals of different transport investments to make things measurable in a comparable manner (see Laird, Nellthorp, & Mackie, 2005). Although our data is not comprehensive enough to allow such calculations, a very simplified mind game reveals the potential significance of the travel time savings from the economic point of view.

Let's assume there would be 1000 bicycles in the system as proposed and approximately eight trips per day were to be made by

each bike, as a modest guess based on international experiences (Helsinki City Transport, 2008). This would mean 8000 trips each day. If an average time saving of a trip would be 6 min and the system would be operational 180 days per year, this would mean 800 saved hours per day and 144 000 saved hours per year. If a cost of 7.75 euro is used to value one hour (as generally in Finnish transport planning, The Finnish Transport Agency, 2010), a BSS would create a time saving worth of 1 116 000 € per year. This exceeds significantly the estimated yearly maintenance cost of BSS (800 000 €) (Helsinki City Transport, 2008).

In addition to travel time calculations, our analyses yielded concrete suggestions for appropriate locations of shared bike stations. As the locations of the largest shared bike hubs show, shared bikes seem to combine especially well with metro and train lines in Greater Helsinki. The flexibility of a shared bike supplements the speed of the rail lines to create a door-to-door public transport connection. The essential difference from traditional public transport system is that one does not have to wait for the next public transport connection because a shared bike can be hired immediately, which, according to Keijer and Rietveld (2000) is a crucial element of satisfaction when using several transport lines in a single trip.

In all, our results suggest that it is possible that a large-scale BSS could complement a traditional public transport system and thereby improve accessibility by public transportation. Thus, already at the planning stage, a bicycle sharing system should be viewed as part of the public transport system, rather than as a separate cycling scheme.

Open data for travel time analysis

As this analysis has shown, the application programming interfaces of public transportation schedules clearly serve research purposes although the interface has originally been opened to support the development of mobile solutions and small-scale businesses (Hielkema & Hongisto, 2013). Indeed, the possibilities of public transport data originally designed for consumer applications have only recently been discovered on the research front (Lei & Church, 2010; Martin et al., 2008). While we used Journey Planner API, which is designed for Helsinki and Finland, a machine readable query interfaces allowing batch routing are available in many other cities as well. For example datasets and query interfaces of Google and Open Trip Planner allow similar approaches to be taken for a growing number of cities, albeit with caution on data quality. In countries and cities where no such data sources are available, development practitioners and knowledge managers will be affected by these trends, and requirements of mobilising their data (Davies & Edwards, 2012).

Finally, availability of information about alternative transport options to the general public has been shown to have an impact on the modal and route choices of individuals (Bamberg, 2006). Should a shared bicycle system be established in Helsinki, open data interfaces would also allow the development of applications that support the use of bicycles as part of the travel chain and potentially increase the number of bicycle users in their part.

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